Energize the Future: Risks and Rewards of Nuclear Energy and the Transition Ahead.

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CANDRIAM
A NEW YORK LIFE INVESTMENTS COMPANY

Speaker

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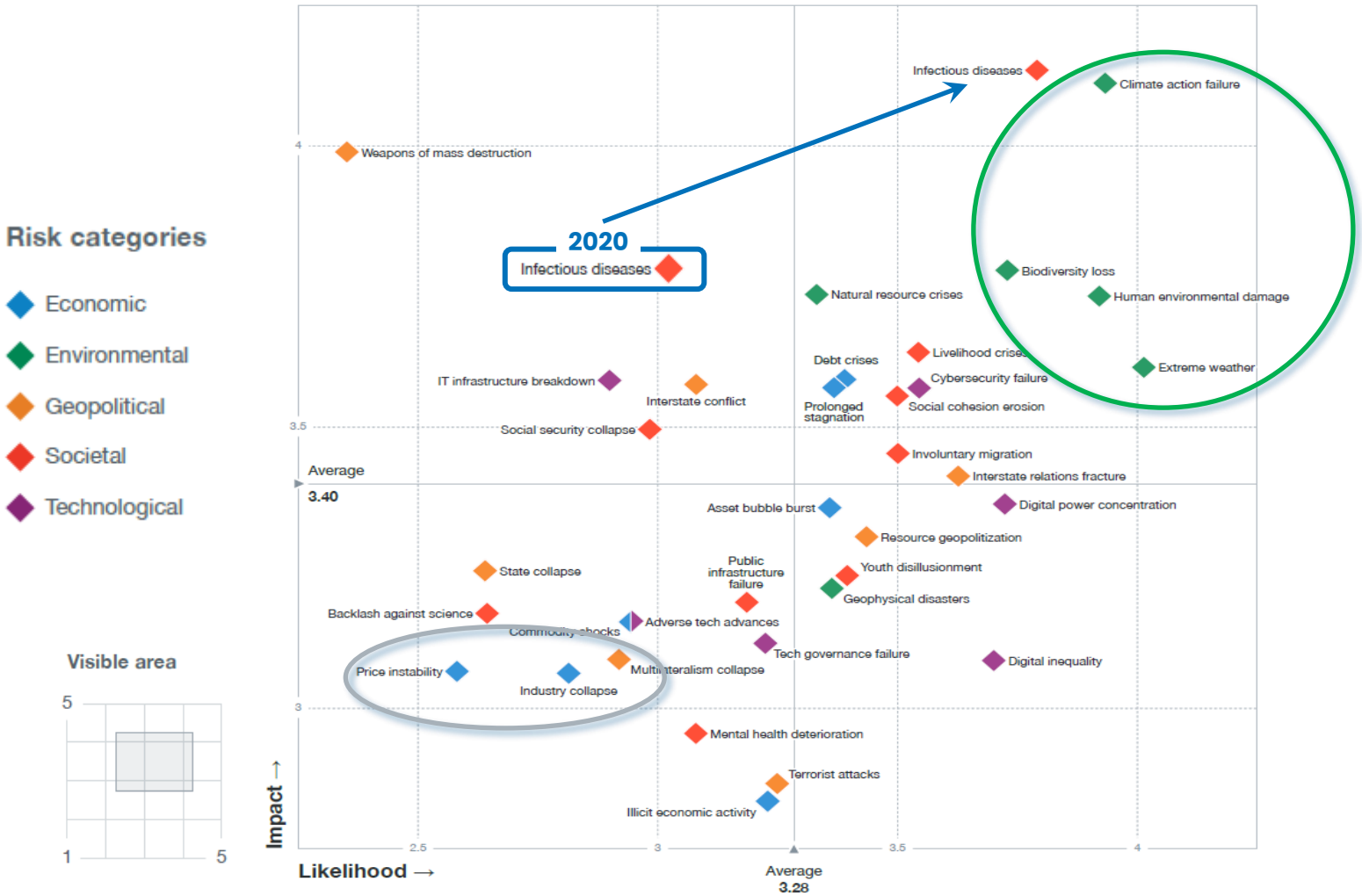
1 Risks & Opportunities in the Current Energy Transition.

ESG Risks Dominate the Global Landscape.

World Economic Forum Global Risk Report 2022

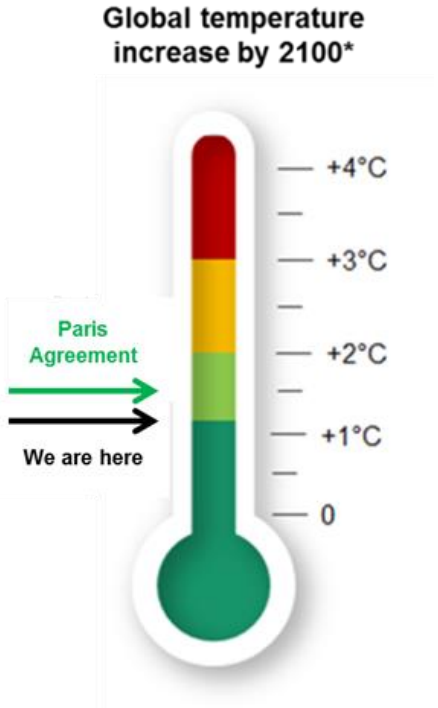


Source: Candriam – World Economic Forum

The Race to Net Zero.

What does it mean?

The Paris agreement and IPCC* reports have underlined the **urgency** of intensifying global mitigation and adaption efforts.



In February 2024

The global average temperature was **1.77C above the pre-industrial average** and marked the ninth month in a row of record heat

Global warming is already having a **significant and costly impact** on our climate, economy, society and broader ecosystem.

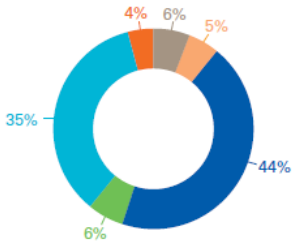
ESG Risks Dominate the Global Landscape.

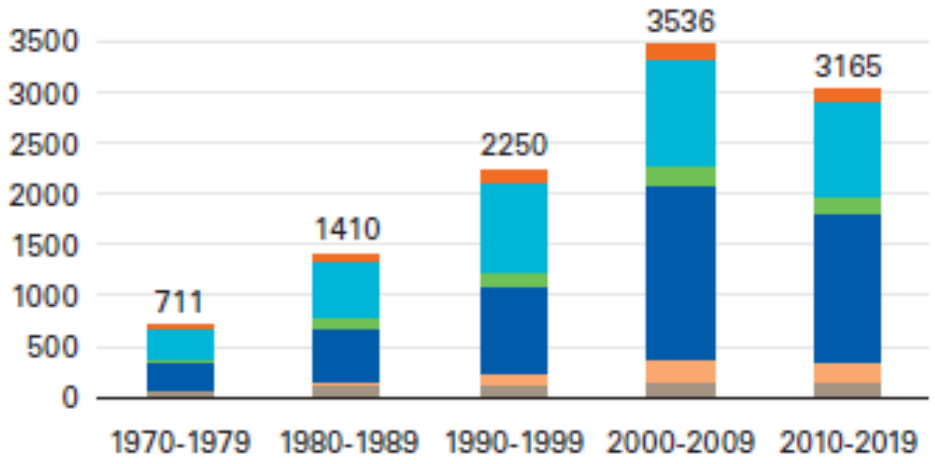
Atlas of Economic Losses from Weather, Climate and Water Extremes (1970 – 2019)

World Meteorological Organization

Number of Reported Disasters

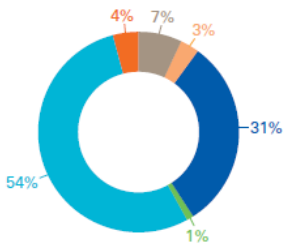
Total = 11.072 Disasters

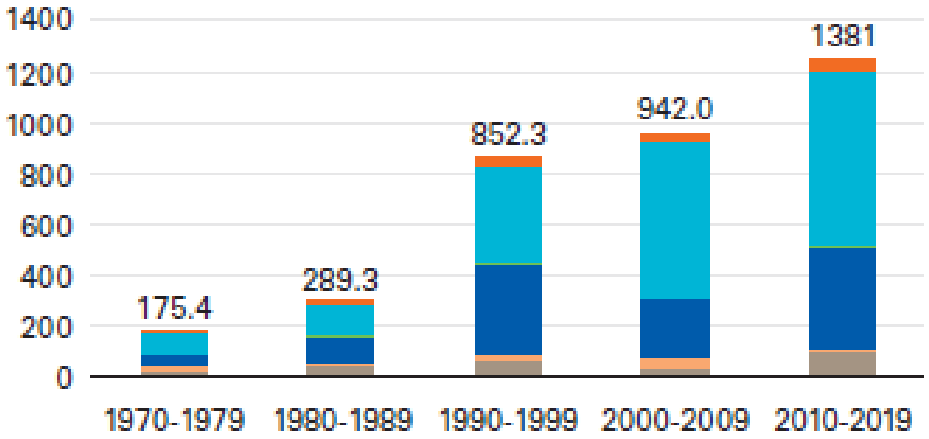




Reported Economic Losses in US$ Billions

Total = US$ 3.6 Trillion





Drought | Extreme temperature | Flood | Landslide | Storm | Wildfire

Source: World Meteorological Organisation

Climate – Towards a Net Zero Carbon World.

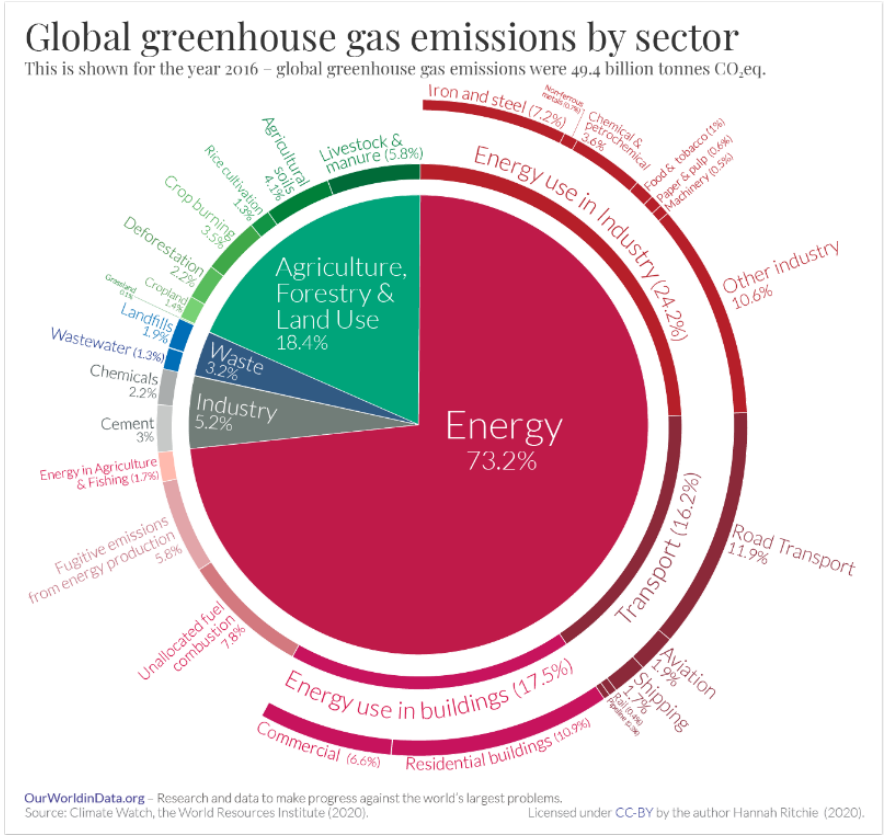
Which proportion of GHG emissions comes from Energy*?

(*) Energy from electricity, heat, used in industry and transport …

1. +/- 25%
2. +/- 50%
3. +/- 75%
4. +/- 90%

Climate – Towards a Net Zero Carbon World.

Decarbonizing the global economy by increasing efforts on various domains

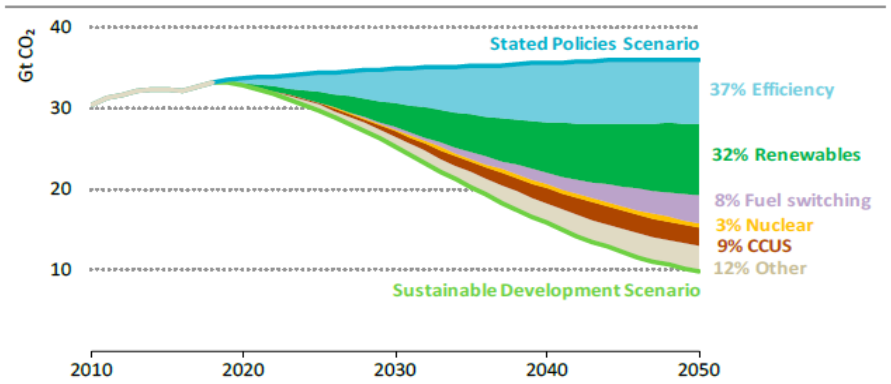


AVOID CARBON EMISSIONS BY

Improving Energy Effiency

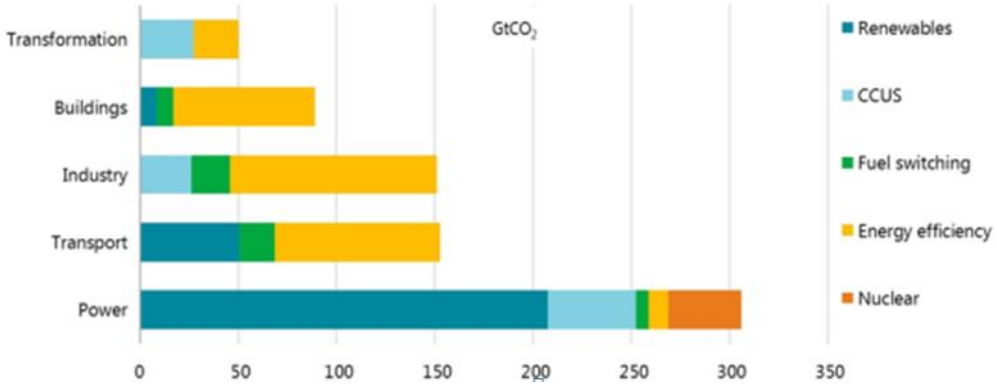
Transition towards Renewable Energy

Low-Carbon Transport Solutions



All clean energy technologies are needed in the Sustainable Development Scenario; energy efficiency is the main contributor to emissions savings to 2050

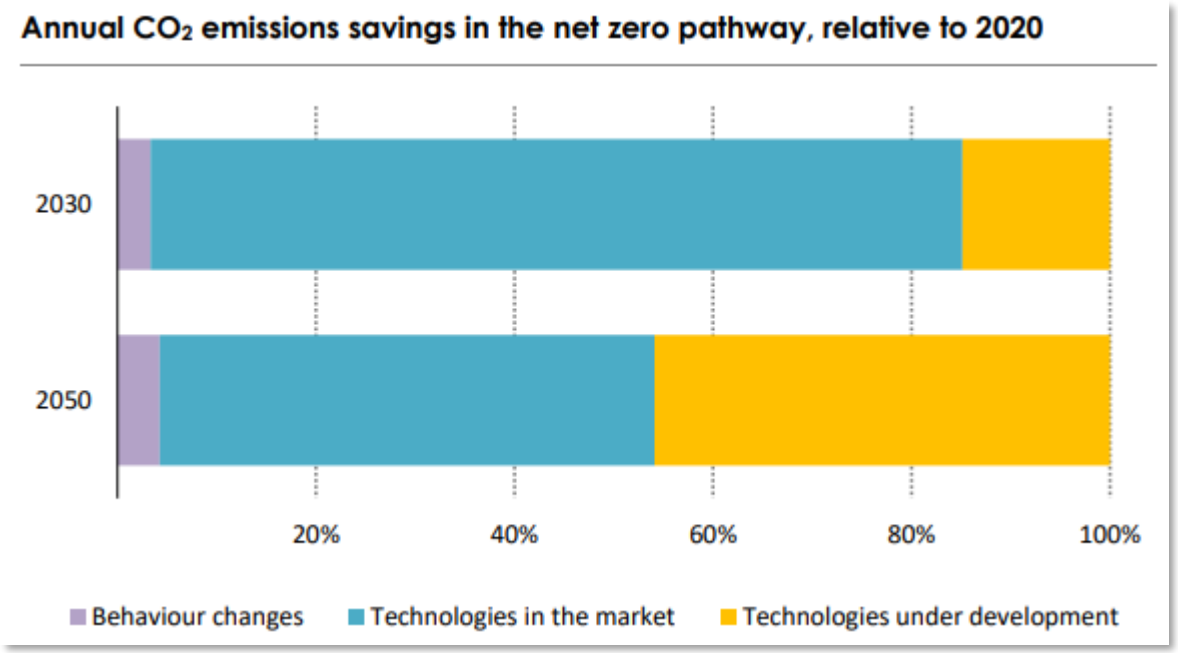
Notes: CCUS = carbon capture, utilisation and storage. Reduced thermal losses in power generation account for 15% of efficiency improvements.

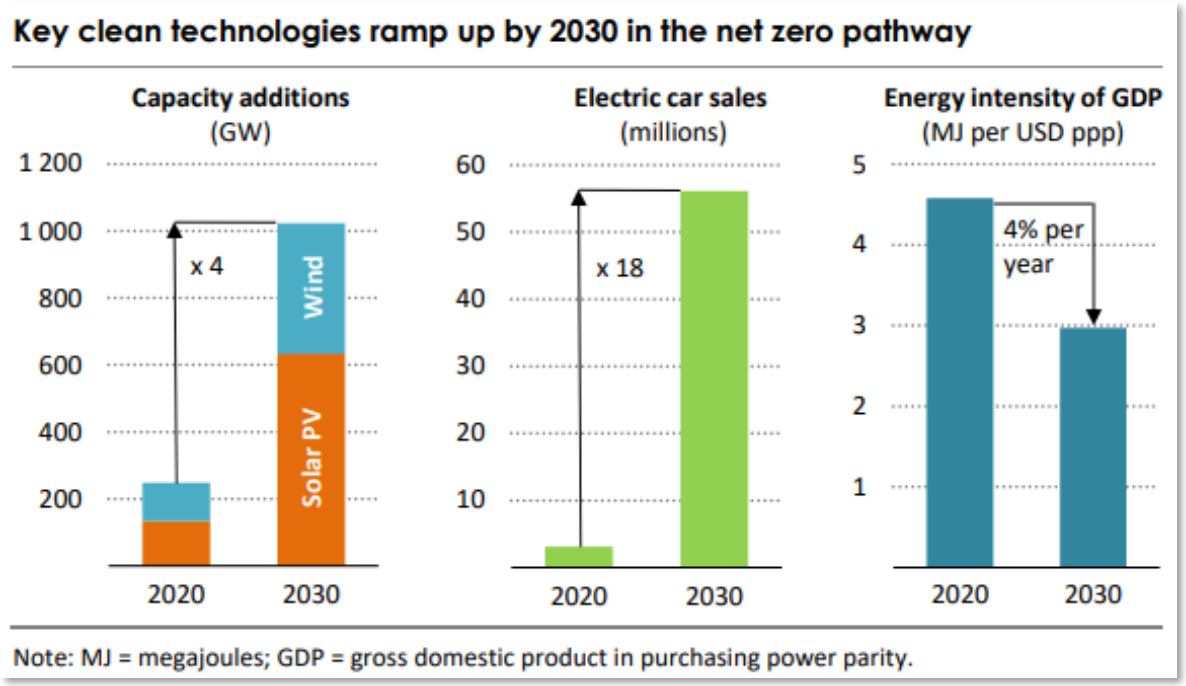


Source: Candriam, IEA, WorldinData

Climate – Towards a Net Zero Carbon World.

All the technologies needed to achieve the necessary deep cuts in global emissions by 2030 already exist …





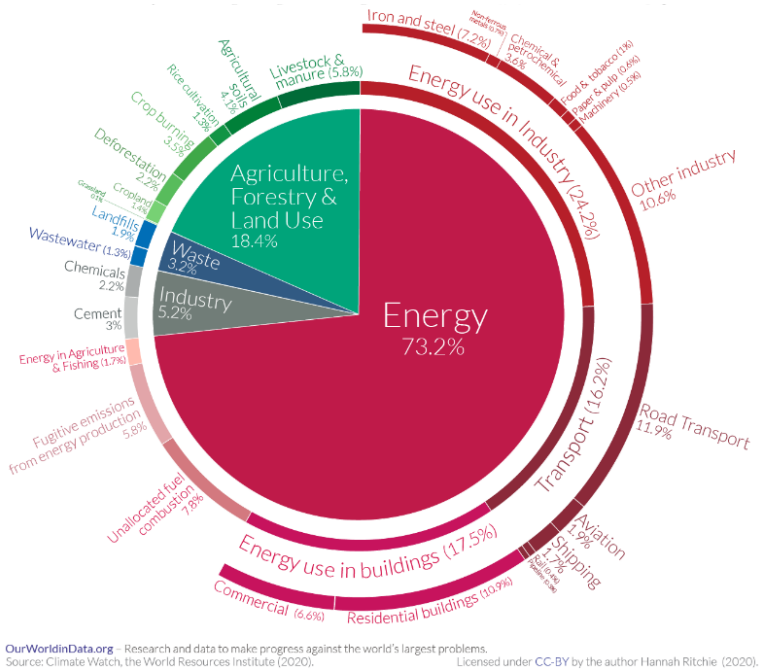
Source: Candriam, IPCC, IEA

2 Nuclear Power.

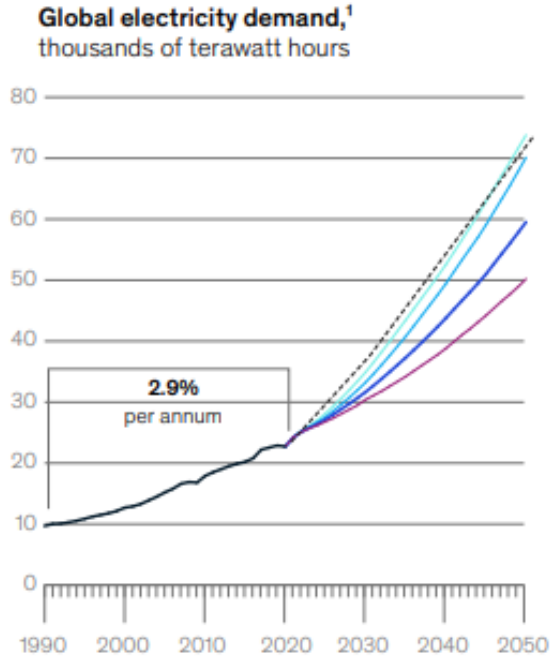
Nuclear Power – Setting the Scene.

- The world emits around **50 billion tonnes of greenhouse** gases each year [measured in carbon dioxide equivalents (CO_2eq)]
- Power generation contributes 30% of global CO_2 emissions, primarily from combustion of fossil fuels.

Global Greenhouse Gas Emissions by Sector



Global Electricity Demand expected to triple by 2050



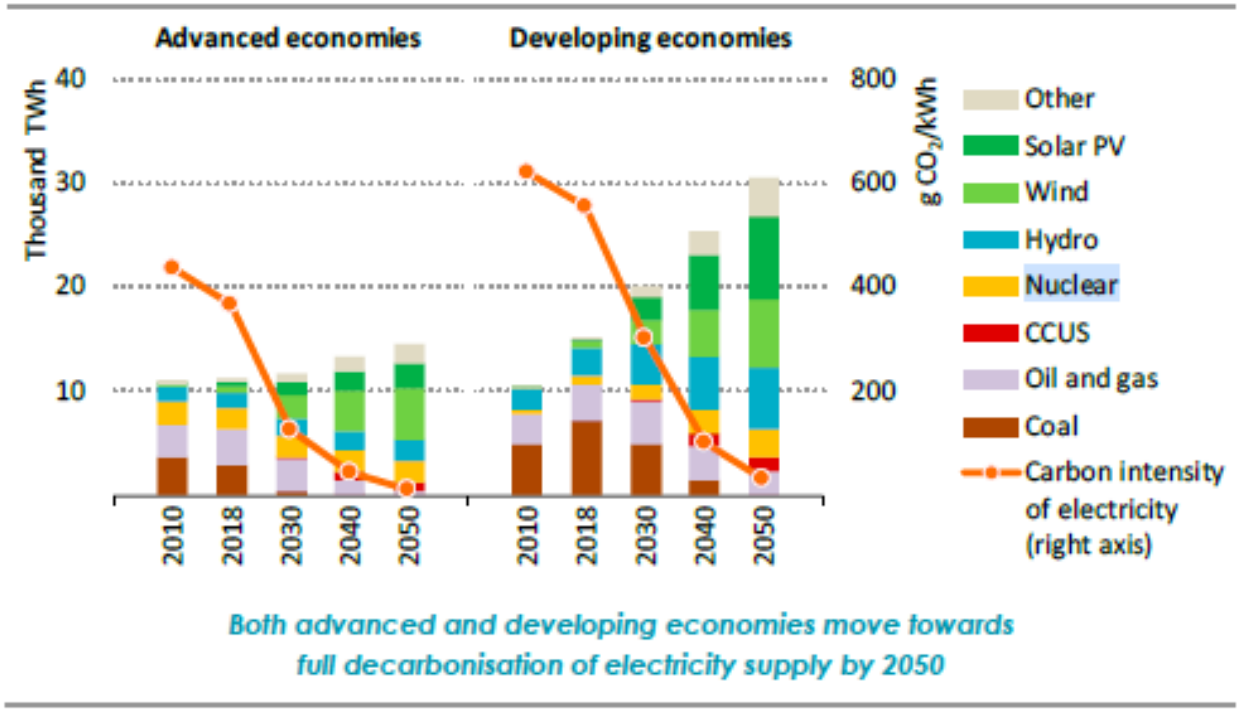
Scenarios[2]	2019–50 CAGR, %
1.5°C pathway Increased regulations and incentives to eliminate greenhouse-gas emissions create the need for extensive electrification across all sectors, including those that are hard to electrify today	3.8
Achieved commitments Technological advance-ment with strict regulations and targets further boost electrification even in sectors that are harder to electrify (eg, high-temp heat industries)	3.8
Further acceleration Technological advancement of proven solutions accelerates cost parity and triggers sooner and stronger electrification (such as heat pump adoption or electric vehicles)	3.7
Current trajectory Consensus view on the key drivers of electricity consumption: increasing living standards and consumption per capita, electrifica-tion across all sectors, and hydrogen uptake	3.1
Fading momentum Slower cost decline of zero-emissions technologies and lower fossil fuel price outlooks limit the fuel-switching trend	2.6

[1]Including demand for green hydrogen production.
[2]Scenarios center around pace of technological progress and level of policy enforcement.

Source: Candriam, WorldinData, McKinsey & Company (2023)

Nuclear Power – The Net Zero Objective.

Electricity Generation by Source and Carbon Intensity of Electricity in a Net Zero Scenario



Note: CCUS = carbon capture, utilisation and storage.

- By 2050, low carbon technologies, most of which are renewables, but also nuclear and CCUS, support well over half of global energy demand, from less than 20% today,
- A reversal of the stable share of fossil fuels at over 80% for the past three decades.
- Nuclear still account for a nearly 10% of energy demand in 2050

Source: World Energy Outlook 2019 - IEA

Nuclear Power – The Net Zero Objective.

Key Advantages

1. Among the **lowest carbon power source**
2. Pushed by global net zero commitments

Very low carbon power source, only carbon-free alternative to coal or other fossil fuels for baseload power

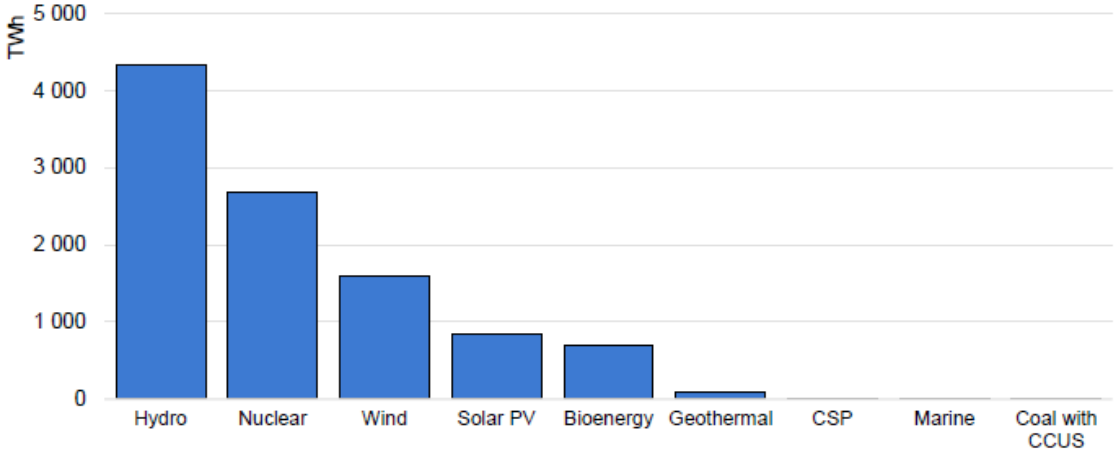
Key Challenges

1. **Long and complex** engineering, procurement & construction
2. High and **increasing costs**

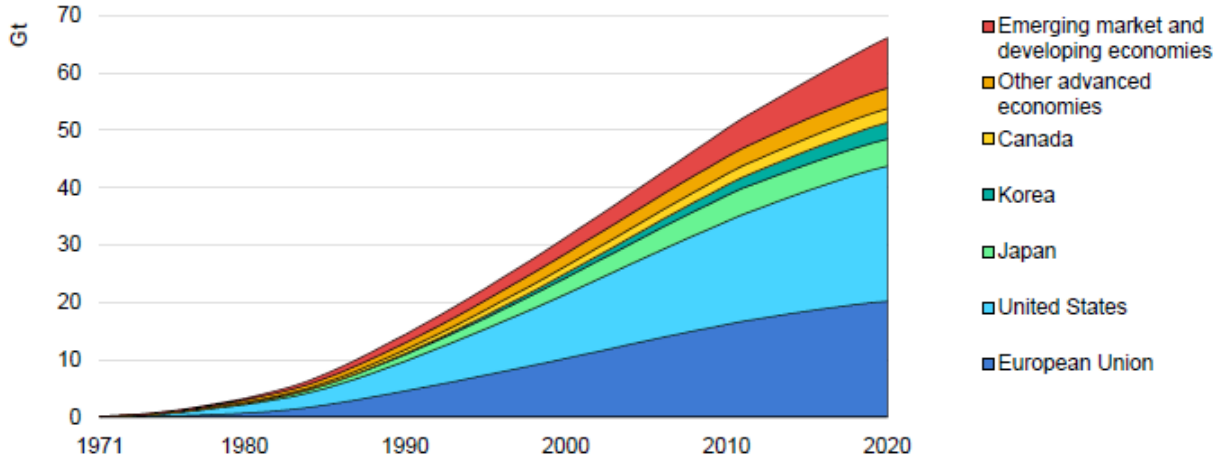
Very long commissioning time, delays, high cost, sustainability issues that play negatively on local acceptance.

Nuclear Power – Low Carbon Power Source.

Low Emissions Electricity Generation by Source Worldwide, 2020



Cumulative CO2 Emissions Avoided by Nuclear Power by Country/Region



Note: CSP = concentrating solar power; CCUS = carbon capture, utilisation and storage.
Source: IEA (2021), World Energy Outlook 2021.

Nuclear is, at this stage, the only low carbon power source that can provide baseload power. ***20-40g CO2/kWh on a lifecycle basis***, which can be in some instances even lower than renewables.

Source:, IEA

Nuclear Power – Low Carbon Power Source.

Emissions of selected electricity supply technologies (gCO2 eq/kWh)

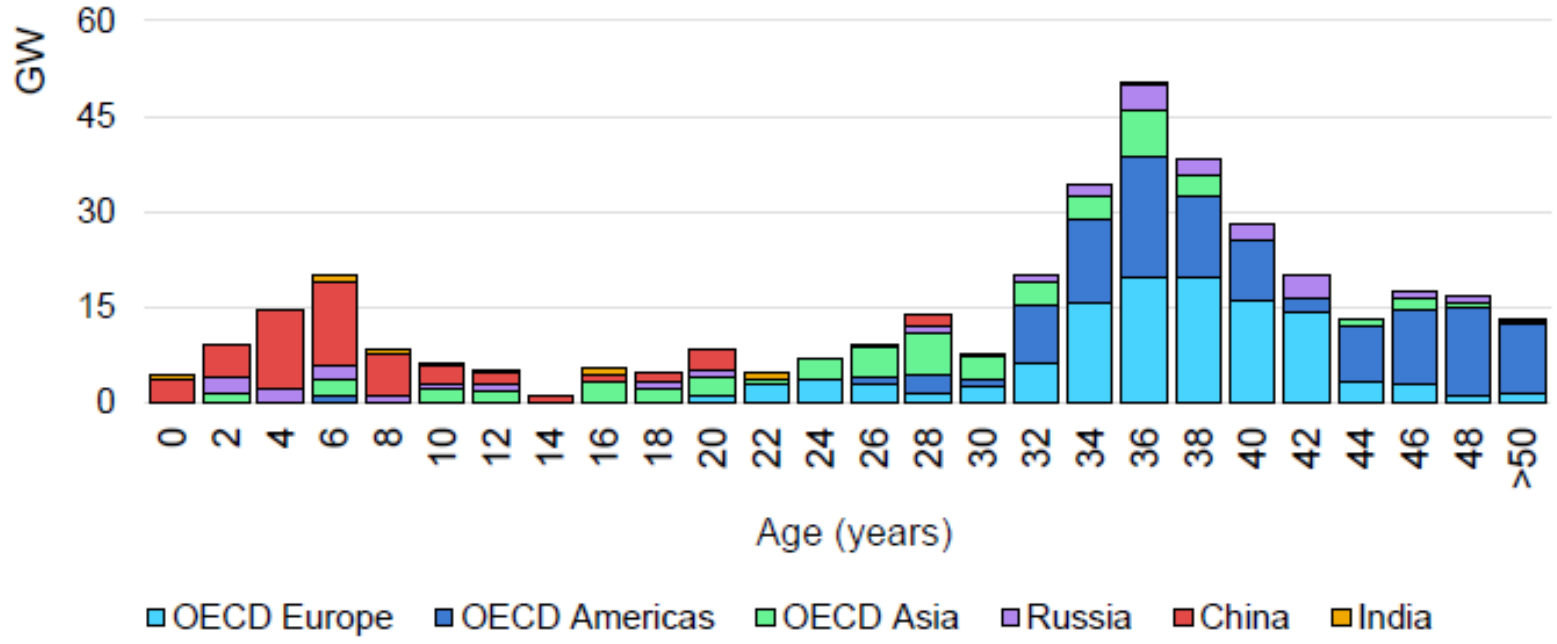
Table A.III.2 | Emissions of selected electricity supply technologies (gCO_2eq/kWh)

Options	Direct emissions	Infrastructure & supply chain emissions	Biogenic CO_2 emissions and albedo effect	Methane emissions	Lifecycle emissions (incl. albedo effect)
	Min/Median/Max	Typical values			Min/Median/Max
Currently Commercially Available Technologies					
Coal—PC	670/760/870	*9.6*	*0*	*47*	**740/820/910**
Gas—Combined Cycle	350/370/490	*1.6*	*0*	*91*	**410/490/650**
Biomass—cofiring	n.a.	–	–	–	**620/740/890**
Biomass—dedicated	n.a.	*210*	*27*	*0*	**130/230/420**
Geothermal	0	*45*	*0*	*0*	**6.0/38/79**
Hydropower	0	*19*	*0*	*88*	**1.0/24/2200**
Nuclear	0	*18*	*0*	*0*	**3.7/12/110**
Concentrated Solar Power	0	*29*	*0*	*0*	**8.8/27/63**
Solar PV—rooftop	0	*42*	*0*	*0*	**26/41/60**
Solar PV—utility	0	*66*	*0*	*0*	**18/48/180**
Wind onshore	0	*15*	*0*	*0*	**7.0/11/56**
Wind offshore	0	*17*	*0*	*0*	**8.0/12/35**
Pre-commercial Technologies					
CCS—Coal—Oxyfuel	14/76/110	*17*	*0*	*67*	**100/160/200**
CCS—Coal—PC	95/120/140	*28*	*0*	*68*	**190/220/250**
CCS—Coal—IGCC	100/120/150	*9.9*	*0*	*62*	**170/200/230**
CCS—Gas—Combined Cycle	30/57/98	*8.9*	*0*	*110*	**94/170/340**
Ocean	0	*17*	*0*	*0*	**5.6/17/28**

Source: IPCC

Nuclear Power – High and Increasing Costs.

Age distribution of operational nuclear capacity by region, end of 2021



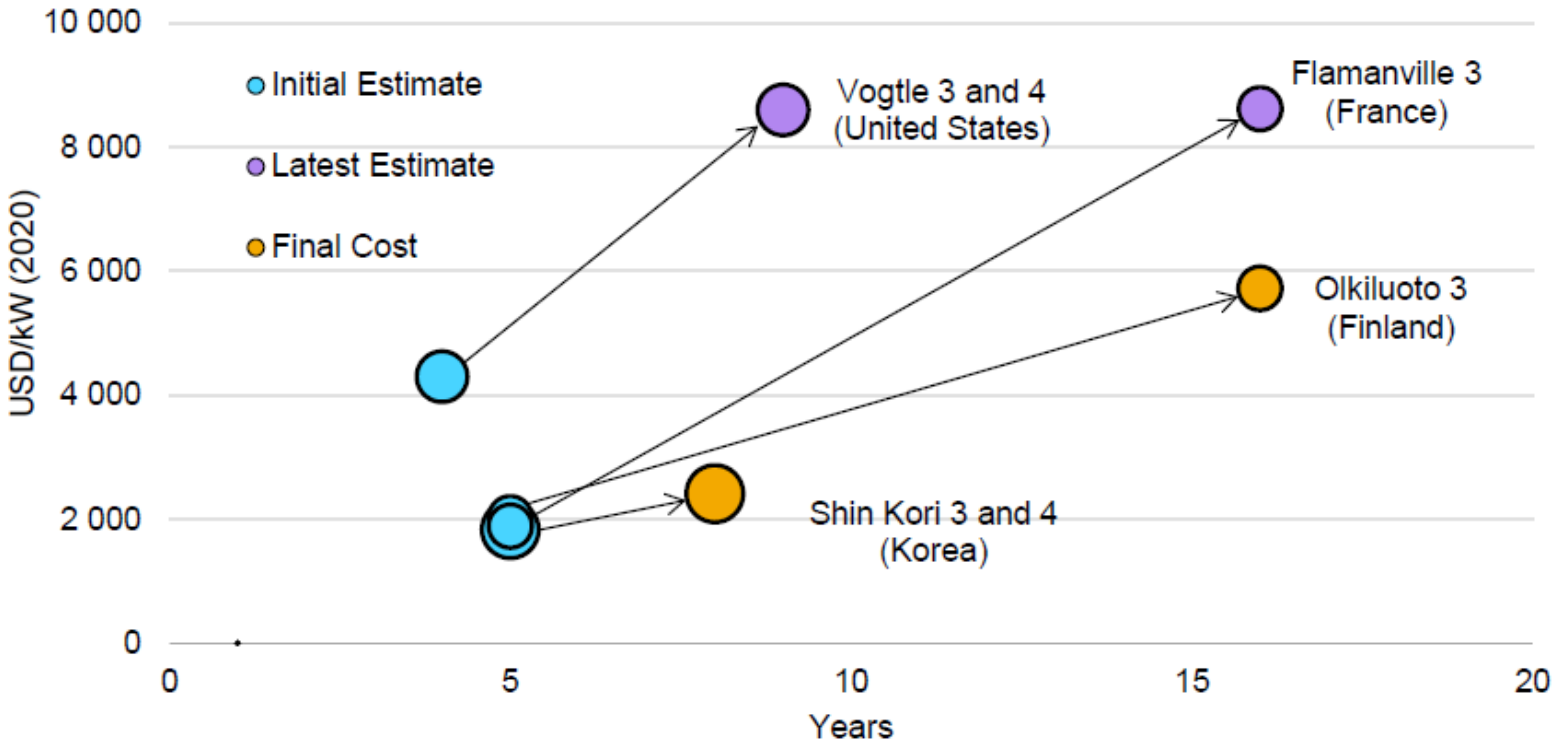
Note: OECD Europe includes Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom. OECD Americas includes Canada, Mexico and the United States. OECD Asia includes Japan and Korea.

Source: IAEA Power Reactor Information System (PRIS).

Source: IEA

Nuclear Power – High and Increasing Costs.

Construction Costs and Times for Some Recent Nuclear Power Plans



Source: Nuclear Energy Agency (2020), Unlocking Reductions in the Construction Costs of Nuclear, IEA

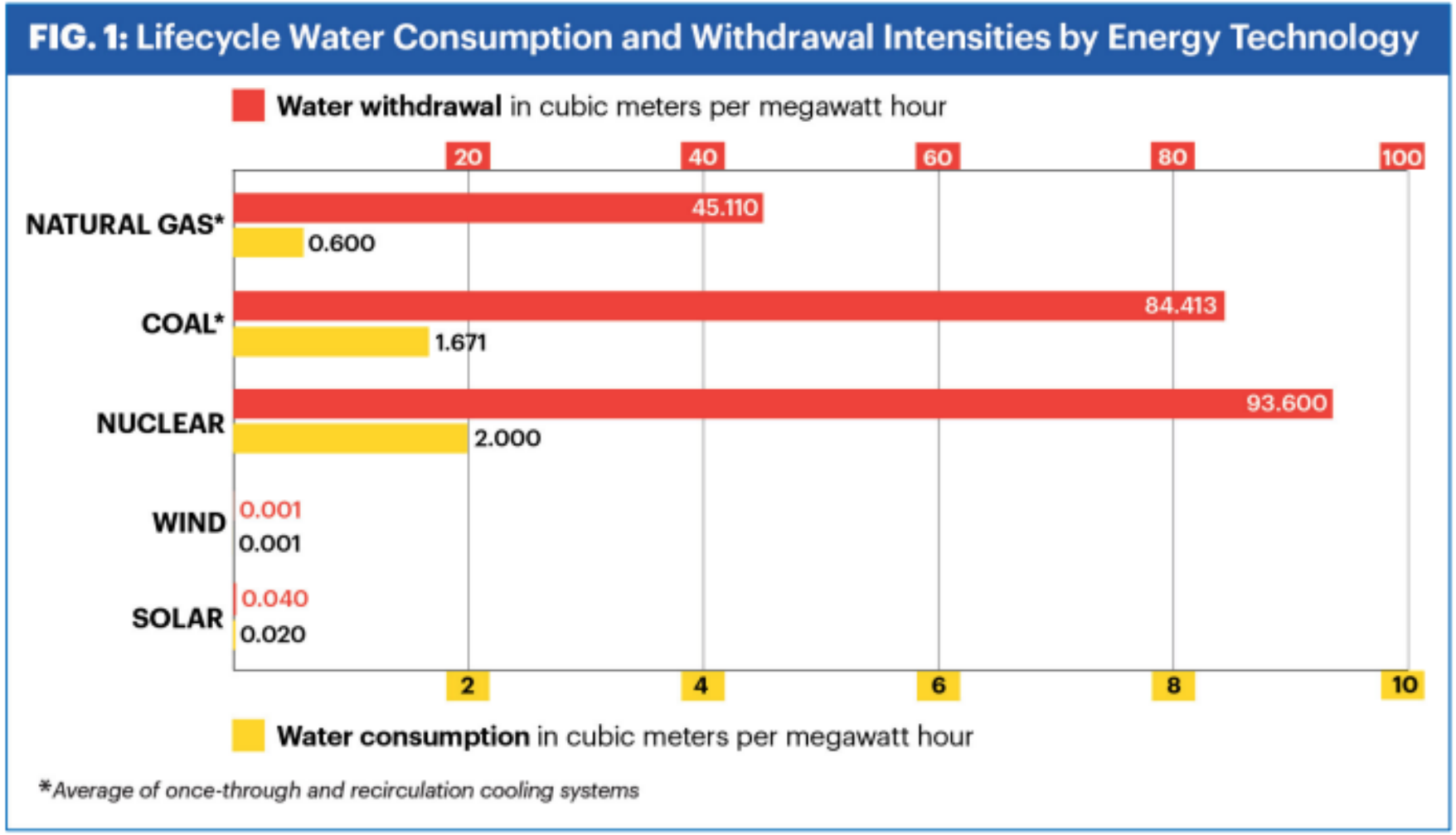
Nuclear Power – High and Increasing Costs.

	Financing rate (%)	Capital costs ($/kW)			Capacity factor (%)			Fuel, CO_2 and O&M ($/MWh)			LCOE ($/MWh)		
	All	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050
United States													
Nuclear	8.0	5 000	4 800	4 500	90	80	75	30	30	30	105	110	110
Coal	8.0	2 100	2 100	2 100	20	*n.a.*	*n.a.*	90	170	235	220	*n.a.*	*n.a.*
Gas CCGT	8.0	1 000	1 000	1 000	55	25	*n.a.*	50	80	105	70	125	*n.a.*
Solar PV	3.7	1 140	620	420	21	22	23	10	10	10	50	30	20
Wind onshore	3.7	1 540	1 420	1 320	42	43	44	10	10	10	35	35	30
Wind offshore	4.5	4 040	2 080	1 480	42	46	48	35	20	15	115	60	40
European Union													
Nuclear	8.0	6 600	5 100	4 500	75	75	70	35	35	35	150	120	115
Coal	8.0	2 000	2 000	2 000	20	*n.a.*	*n.a.*	120	205	275	250	*n.a.*	*n.a.*
Gas CCGT	8.0	1 000	1 000	1 000	40	20	*n.a.*	65	95	120	100	150	*n.a.*
Solar PV	3.2	790	460	340	13	14	14	10	10	10	55	35	25
Wind onshore	3.2	1 540	1 420	1 300	29	30	31	15	15	15	55	45	40
Wind offshore	4.0	3 600	2 020	1 420	51	56	59	15	10	5	75	40	25

- **O&M = Operation and Maintenance**
- **LCOE = Levelized Cost of Electricity**
- **kW = kilowatt**
- **MWh = megawatt-hour**

Source: : IEA analysis; IRENA Renewable Costing Alliance; IRENA (2020).

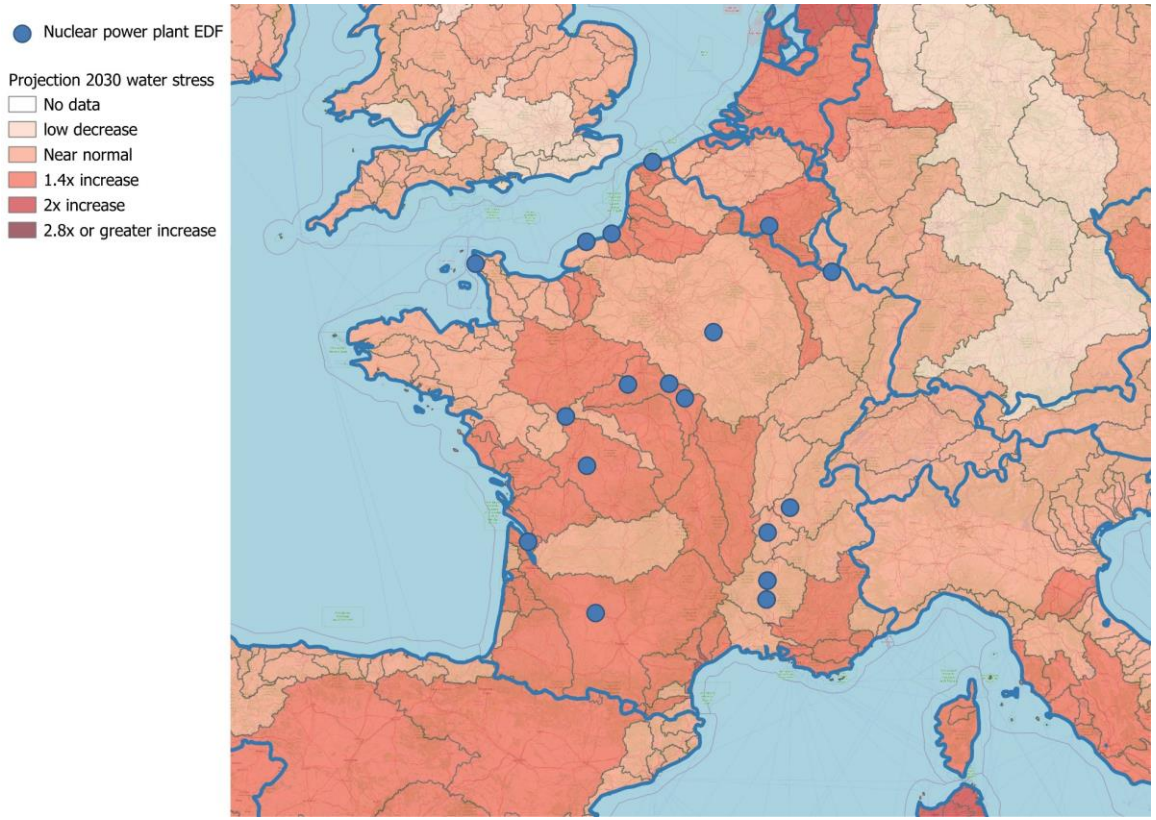
Nuclear Power – The Unknown Externality Costs.

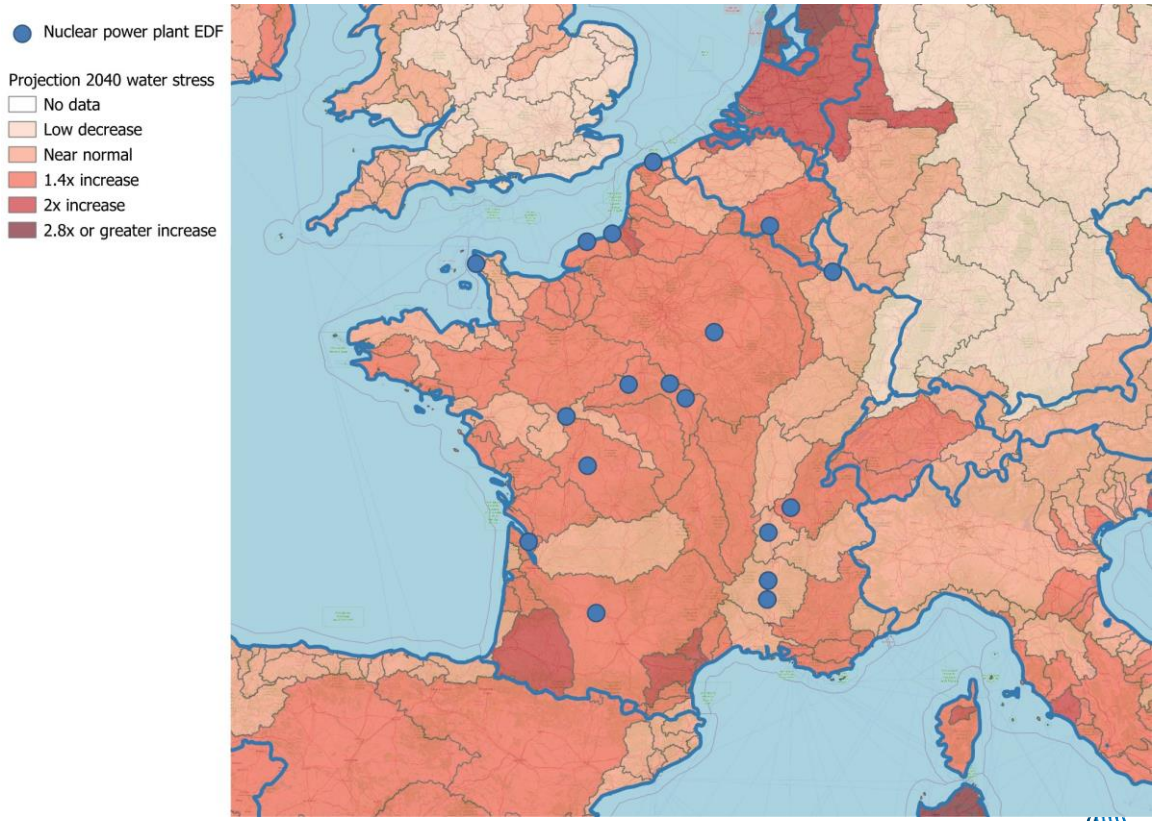


DATA SOURCE: Food & Water Watch (FWW) analysis of Kondash et al. (2019)

Nuclear Power – EDF Water Stress Exposure.

- In 2022, EDF faced significant challenges related to water at several of its nuclear facilities.
- These issues stemmed from unusually low water levels in rivers caused by prolonged periods of drought and higher-than-average water temperatures during heatwaves
- The water issues led to decreased efficiency and, in some cases, temporary shutdowns of reactors to ensure safety and comply with environmental regulations regarding water use and temperature thresholds for discharge.





Sustainability perspective.

Key risks and challenges

01 Accident risks

- **Devastating effects** on the environment and the local populations' health;
- Largest and most impactful accident over recent years was Fukushima in 2011.

02 Water consumption

- **Relies much more heavily on water** than most other low-carbon energy sources
- Important droughts may **reduce** the amount of surface **water available for cooling**

03 Hazardous nuclear waste

- The entire nuclear power cycle **produces hazardous nuclear waste**
- Low-level radioactive waste takes +100 of years to achieve adequate levels of safety

04 Skills shortage

- **Finding skilled workers is a key challenge** for the global nuclear industry
- Key **challenge both for the maintenance of existing operations** and in building new capacities

Candriam's view.

SUSTAINABILITY CHALLENGES

- Some **advantages in terms of climate and security**, but raises operational, cost and **sustainability concerns**;
- Deciding on the right level of nuclear investments and **share in the energy mix is a government/citizen matter**;
- **Pure nuclear players are still government owned**, and that governments tend to increase their influence rather than exit in these companies.

PROS OR CONS

- **Not in favour or opposed** to nuclear;
- **Ponder carefully the pros and cons in investing in companies** exposed to nuclear, and we stick to what our clients' views and values require us to do;
- Candriam applies revenue threshold in terms of its exposure to Nuclear Power. **Our sustainable strategies** advocate a diversified mix of power generation, but excludes pure players;
- **Carefully monitoring the position of nuclear in coming regulation**, including the EU taxonomy.

3 Rare Earth Metals & Electrification.

ESG Risks Dominate the Global Landscape.

World Economic Forum Global Risk Report 2022

Source: Candriam, World Economic Forum

Geopolitical events enforce urgency.

EU AVERAGE 2020
57.5% Energy Dependency

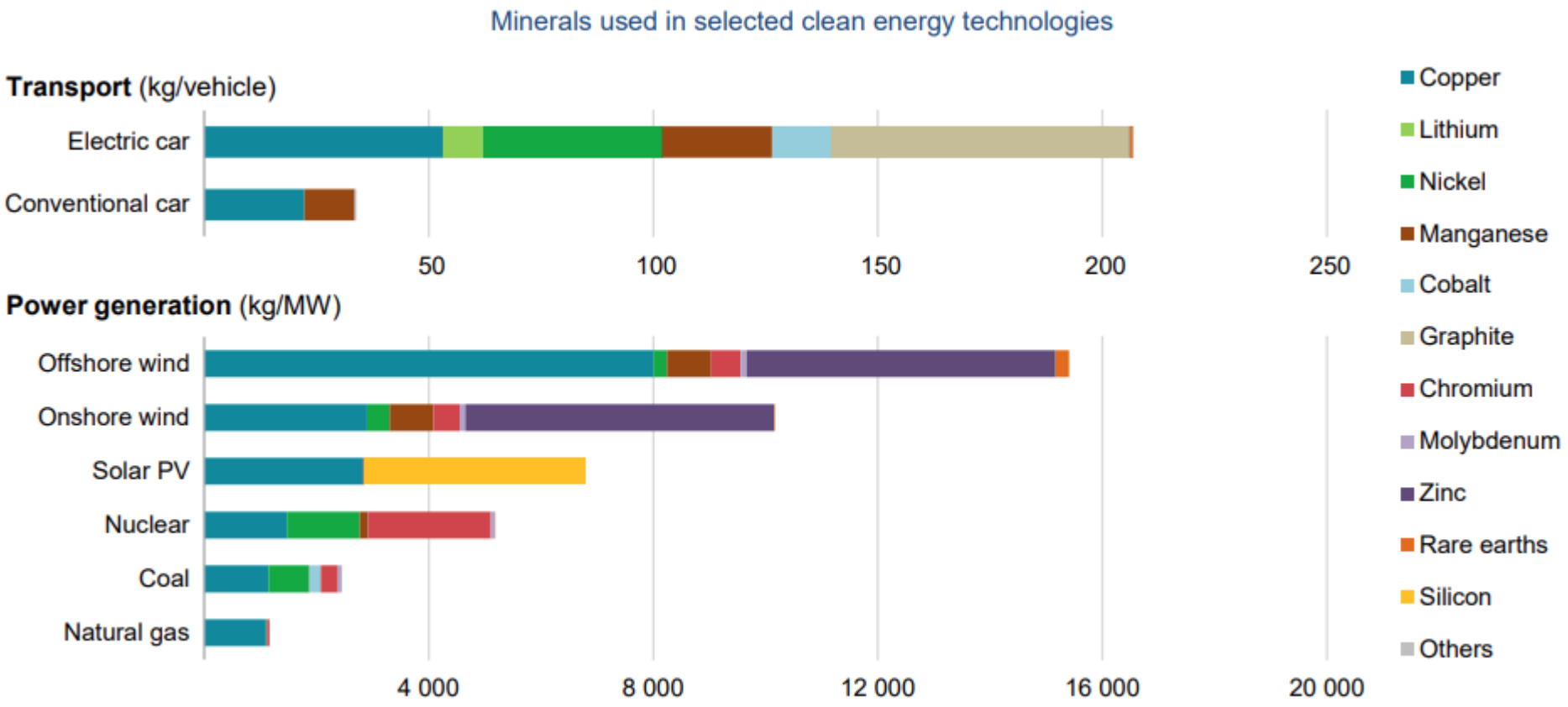
EU IMPORTS 2020

Crude Oil 26.9% from Russia
Coal 46.7% from Russia
Natural Gas 41.1% from Russia

Reliance on fossil fuels prevents energy independence

Source: Eurostat, EIA, Statista, 2021

Energy transitions implies a significant increase in demand for minerals.

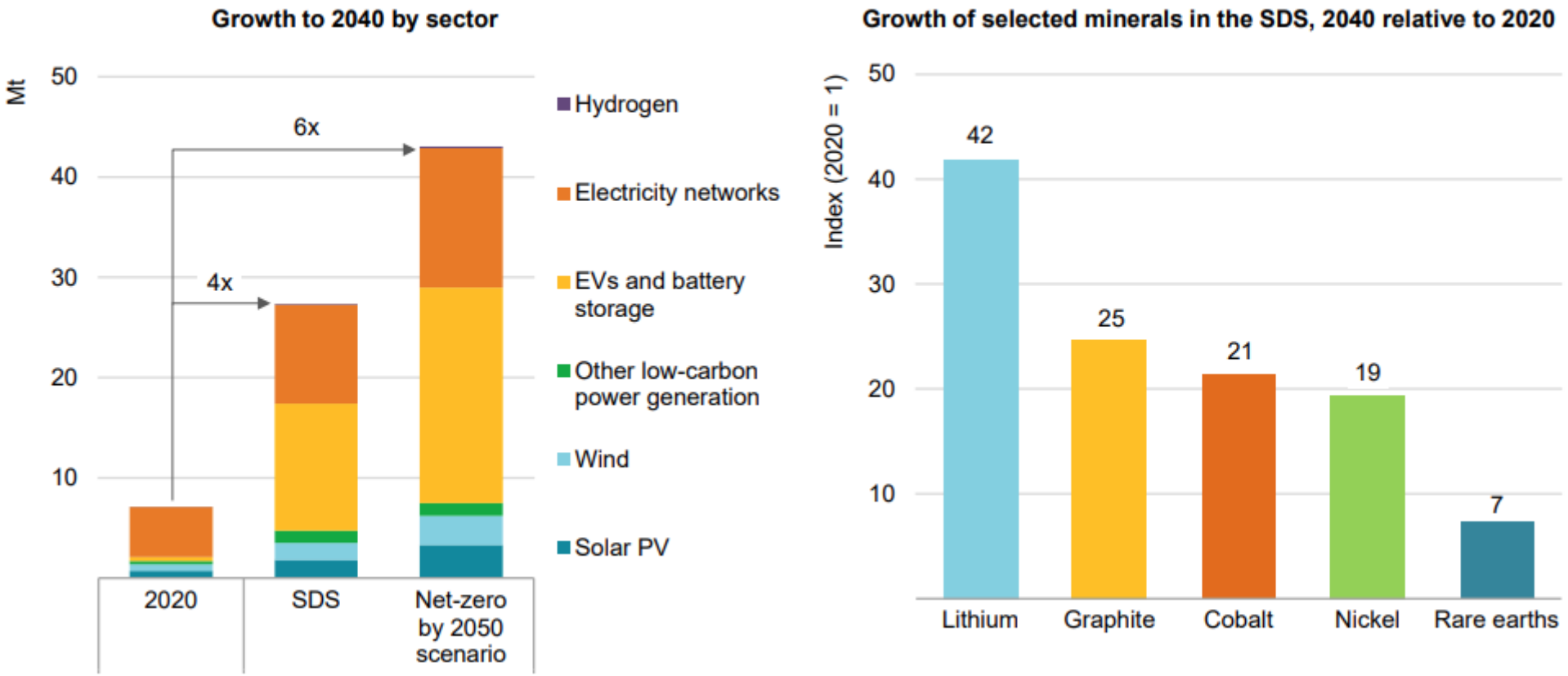


Source: : IEA

Notes: kg = kilogramme; MW = megawatt. Steel and aluminium not included.

Mineral demand for clean energy technologies would rise by at least four times by 2040 to meet climate goals.

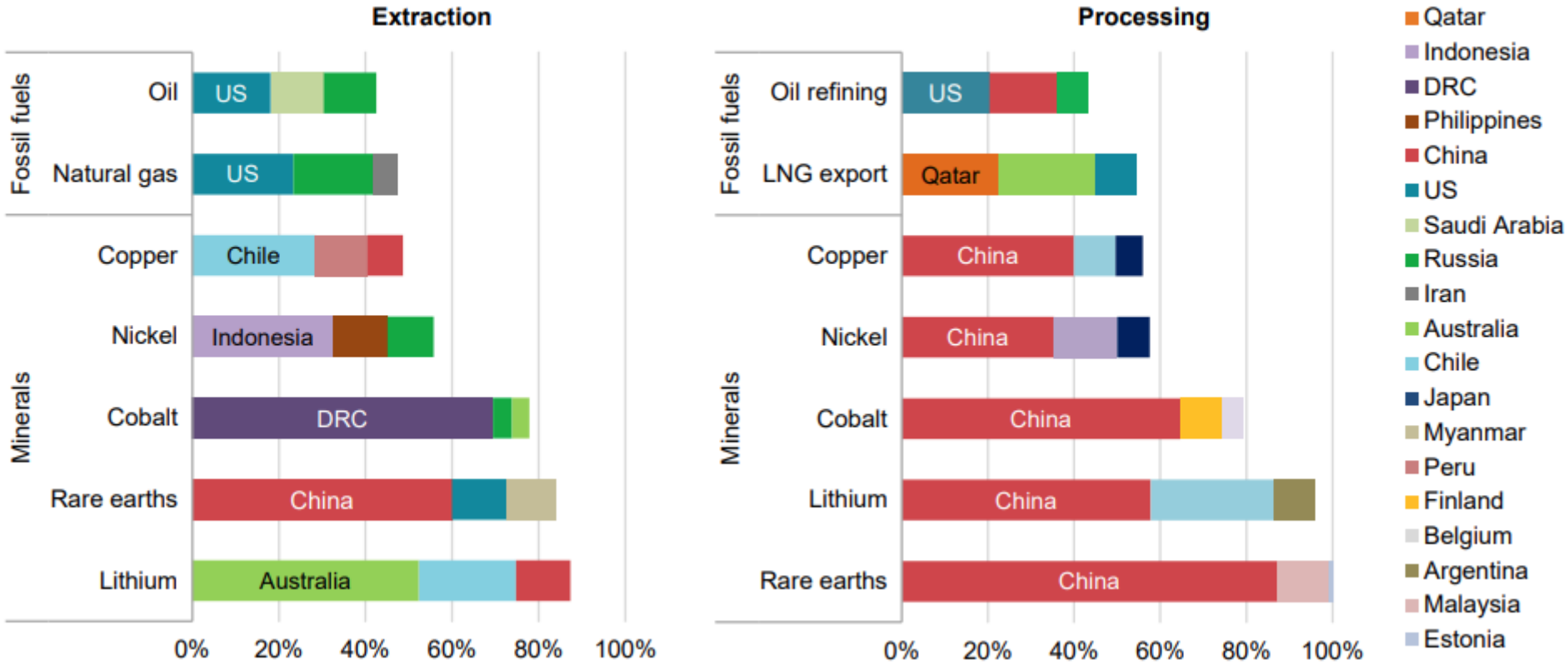
Mineral demand for clean energy technologies by scenario



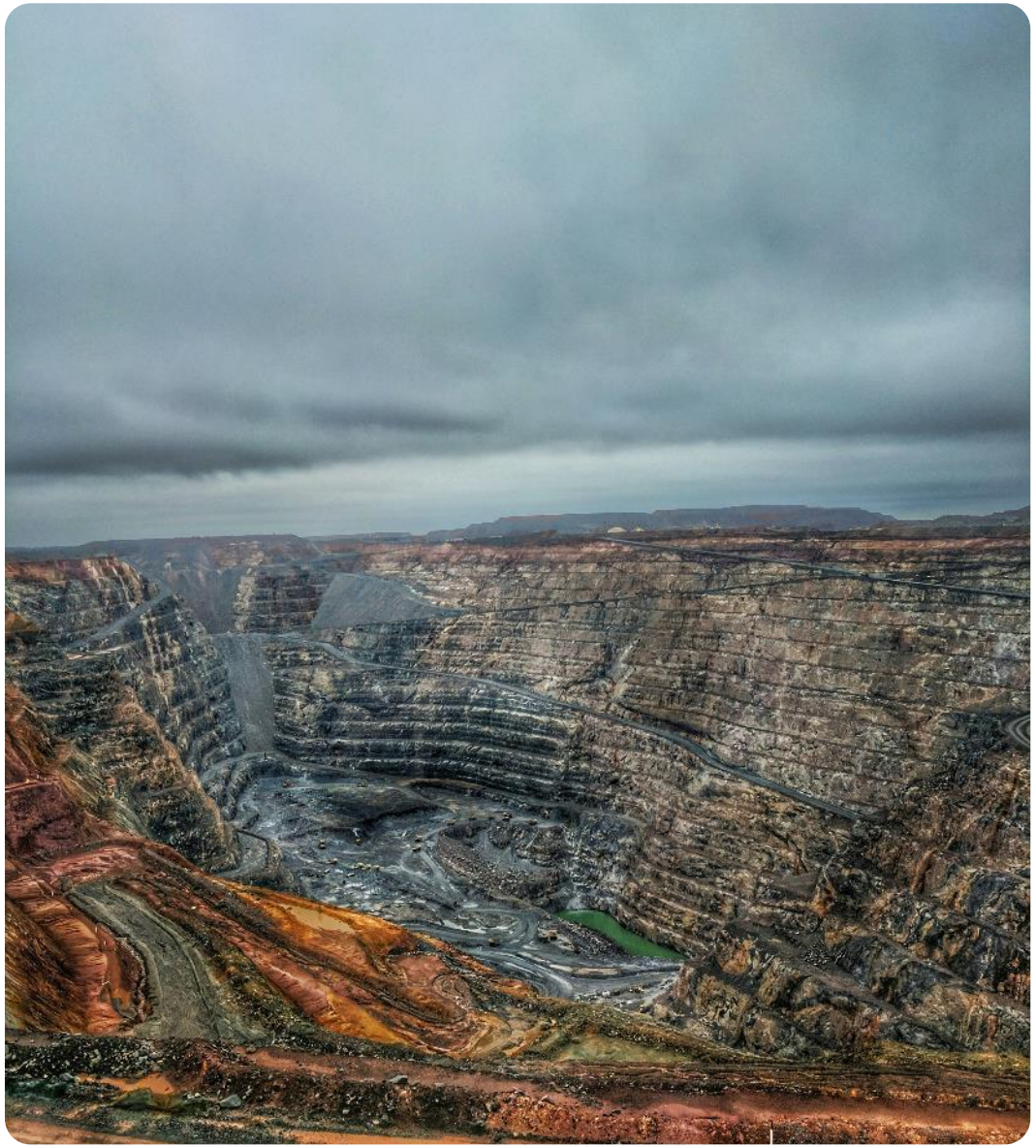
Source: IEA

Minerals are more geographically concentrated than that of oil or natural gas.

Share of top three producing countries in production of selected minerals and fossil fuels, 2019



Sources: IEA (2020a); USGS (2021), World Bureau of Metal Statistics (2020); Adamas Intelligence (2020).



Metal and Mining companies are considered very problematic by many investors.

As we have seen , they are essentials enabling transportation companies to hit their emissions targets.

As investors, where do we go from here?

What makes Candriam an ESG Leader?

Track record

Over 25 years of successfully combining sustainability and financial objectives and building in-house ESG expert teams and databases

Research

Expert ESG Analyst Team develops & implements tried and tested **proprietary frameworks** for fundamental corporate and sovereign ESG analysis

Active shareholder

Dedicated voting and engagement team advances sustainability of issuers and informs investment decision-making ESG practices

Impact

Detailed, transparent ESG reporting

Walking the talk on **corporate responsibility** through education, public debate and charitable projects

Agility & Innovation

Sustainable investments across asset classes, **thematic innovation** and **tailor-made sustainable solutions**

ESG Partner

Partner to investors in their journey towards sustainability through various **ESG-related services**

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